REMARKS

The above amendments to the above-captioned application along with the following remarks are being submitted as a full and complete response to the Office Action dated August 9, 2005. In view of the above amendments and the following remarks, the Examiner is respectfully requested to give due reconsideration to this application, to indicate the allowability of the claims, and to pass this case to issue.

Status of the Claims

Claims 1, 2 and 4-10 are under consideration in this application. Claims 1-2 and 8-9 are being amended, as set forth in the above marked-up presentation of the claim amendments, in order to more particularly define and distinctly claim applicants' invention, and to correct formal errors and/or to better recite or describe the features of the present invention as claimed. All the amendments to the claims are supported by the specification. Applicants hereby submit that no new matter is being introduced into the application through the submission of this response.

Prior Art Rejections

The Examiner rejected claims 1-2, 5-6 and 8-10 under 35 U.S.C. 103(a) on the grounds of being unpatentable over Doerner et al. (US Patent No. 6,537,684). Claim 4 was rejected under 35 U.S.C. 103(a) on the grounds of being unpatentable over Doerner '684 in view of Wang et al. (US Application No. 2002/0098389). Claim 7 was rejected under 35 U.S.C. 103(a) on the grounds of being unpatentable over Doerner '684 in view of Sakawaki et al. (US Application No. 2002/0160234). Applicants have carefully considered the above rejections, but hereby respectfully traverse.

The present invention as now recited in claim 1 is directed to a magnetic recording medium comprising: a substrate; an underlayer formed over the substrate, the underlayer including Cr and Ti; a magnetic recording layer formed directly on the underlayer, having a first magnetic layer, a second magnetic layer and, a non-magnetic intermediate layer formed between the first magnetic layer and the second magnetic layer, wherein the first magnetic layer consisting of Co, Pt, and Cr and formed directly on the underlayer that includes Cr and Ti. The non-magnetic intermediate layer formed directly on the first magnetic layer contains at least one element selected from the group consisting of Ru, Ir, and Rh. The second magnetic layer formed directly on the non-magnetic intermediate layer contains Co as a main

component. The first magnetic layer and the second magnetic layer are magnetized in the antiparallel direction in the absence of an applied magnetic field, and the first magnetic layer is formed to contain an amount of Pt no less than 3 at% and no more than 9 at% so as to improve a signal-to-noise ratio of the magnetic recording medium.

The present invention as recited in claim 2 is directed to a magnetic recording medium including a substrate and a magnetic recording layer formed thereon with an underlayer interposed between them, wherein the magnetic recording layer comprises: a first magnetic layer containing only Co, Cr and Pt formed directly on the underlayer, a second magnetic layer, and a non-magnetic intermediate layer formed between the first magnetic layer and the second magnetic layer. The first magnetic layer and the second magnetic layer are magnetized in the antiparallel direction in the absence of an applied magnetic field. The first magnetic layer being formed to contain an amount of Pt that is no less than 3 at % and no more than 9 at % so as to improve a signal-to-noise ratio of the magnetic recording medium, wherein the magnetic recording layer is formed directly on the underlayer, the underlayer includes Cr and Ti, the non-magnetic intermediate layer is formed directly on the first magnetic layer, and the second magnetic layer is formed directly on the non-magnetic intermediate layer.

The present invention as recited in claim 8 is directed to a magnetic storage which comprises a magnetic recording medium, a drive unit to turn the magnetic recording medium, a magnetic head consisting of a writing part and a reading part, a means to move the magnetic head relative to the magnetic recording medium, and a signal processing unit to send and receive signals to and from the magnetic head, wherein the reading part of the magnetic head is a giant magneto-resistive effect element or has a tunnel junction which produces the magneto-resistive effect. The magnetic recording medium is comprised of: a substrate; an underlayer formed over the substrate, the underlayer including Cr and Ti; and a magnetic recording layer formed directly on the underlayer, having a first magnetic layer, a second magnetic layer and, a non-magnetic intermediate layer formed between the first magnetic layer and the second magnetic layer. The first magnetic layer comprises only Co, Pt, and Cr and is formed directly on the underlayer that includes Cr and Ti. The non-magnetic intermediate layer formed directly on the first magnetic layer contains at least one element selected from the group consisting of Ru, Ir, and Rh. The second magnetic layer formed directly on the non-magnetic intermediate layer contains Co as a main component. The first

magnetic layer and the second magnetic layer are magnetized in the antiparallel direction in the absence of an applied magnetic field, and the first magnetic layer is formed to contain an amount of Pt that is no less than 3 at% and no more than 9 at% <u>so as to improve a signal-to-noise ratio of the magnetic recording medium</u>.

Lastly, the present invention as recited in claim 9 is directed to a magnetic storage which comprises a magnetic recording medium, a drive unit to turn the magnetic recording medium, a magnetic head consisting of a writing part and a reading part, a means to move the magnetic head relative to the magnetic recording medium, and a signal processing unit to send and receive signals to and from the magnetic head, wherein the reading part of the magnetic head is a giant magneto-resistive effect element or has a tunnel junction which produces the magneto-resistive effect. The magnetic recording medium is one which is comprised of: a substrate and a magnetic recording layer formed thereon with an underlayer interposed between them. The magnetic recording layer comprises: a first magnetic layer containing only Co, Cr and Pt formed directly on the underlayer, a second magnetic layer, and a non-magnetic intermediate layer formed between the first magnetic layer and the second magnetic layer. The first magnetic layer and the second magnetic layer are magnetized in the antiparallel direction in the absence of an applied magnetic field. The first magnetic layer is formed to contain an amount of Pt that is no less than 3 at % and no more than 9 at % <u>so as to improve a signal-to-noise ratio of the magnetic recording medium</u>, wherein the magnetic recording layer is formed directly on the underlayer, wherein the underlayer includes Cr and Ti, the non-magnetic intermediate layer is formed directly on the first magnetic layer, and the second magnetic layer is formed directly on the non-magnetic intermediate layer.

Applicants respectfully contend that none of the cited references teaches or suggests each and every feature of the present invention as now claimed.

Contrary to the Examiner's assertion in the Office Action, Doerner '684 discloses employing CoCr-alloy, CoPtCr-alloy, or CoPtCrTa-alloy, which are the alloys containing no B, to the first magnetic layer. This enables the first magnetic layer to stack directly on the Cr-alloy underlayer without insertion of a nucleation layer such as non-magnetic CoCr-alloy. The allowable Pt content in the CoPtCr-alloy available for the first magnetic layer, as described in Doerner '684 (see col. 6, line 19) is 0-15 at%, and the range is wide enough to cover almost any composition of a conventional CoPtCr-alloy magnetic layer used for the

magnetic recording media. Therefore, Applicants have found that it is very difficult to obtain the CoCrPt-alloy with Pt content range of 3-9 at%, even if optimization is carried out based on the teachings of Doerner '684.

In fact, Applicants will contend that there is no reason for choosing a CoCrPt-alloy containing 3-9 at% Pt according to Doerner '684 or even under normal circumstances. Applicants have found that the Pt addition into the CoCr-alloy is effective in increasing magnetic anisotropy of the magnetic layer, as described in Doerner '684 (see col. 6, line 16-17: "The Pt may be a desired additive if more anisotropy is desired"). When increasing the anisotropy of the magnetic layer is desired, there is no reason for choosing the range of 3-9 at%, because the range of more than 10 at% is typically done for conventional magnetic recording media, which is clear according to the Pt content in the second magnetic layer described in Doerner '684. When improving media SNR is desired, the enhancement of grain isolation by adding Ta or B into CoCrPt-alloy is the typical method known and used in the prior art (see for example the additive effect of Ta described in Doerner '684, col. 6, line 17-18) where "the Ta may be a desired additive if more grain isolation is desired".

The effects of the grain isolation enhancement by Ta or B addition were reported in the Journal of Applied Physics, Volume 84, Number 11, page 6202-6207 (1998). The noise reduction effects by adding Ta into CoCrPt-alloy were reported in, for example, the Journal of Applied Physics, Volume 32, Number 9A, page 3823-3827 (1993). Therefore, Applicants will contend that, in the prior art, it was very difficult to find the way of adding 3-9 at% Pt into CoCr-alloy magnetic layer without adding Ta and B in order to improve media SNR.

The present invention is directed to improving media signal-to-noise ratio (SNR) which is obtained only when the CoCrPt-alloy containing 3-9 at% Pt is employed in the first magnetic layer. The present invention as disclosed shows that the CoCrPt-alloy containing 0-10 at% Pt is not suitable for recording layer and the use of an interface layer is proposed to avoid using it as the recording layer.

In contrast, Doerner '684 teaches the importance of no B alloy for the first magnetic layer and no Pt Alloy, but allows a Ta-containing alloy. Thus, it is clear that the CoCrPt-alloy containing 3-9 at% Pt is not typically used for the magnetic layer and as a result, it would be difficult to find this special composition range by optimization as may be taught by Doerner '684.

Among the main features of the present invention, media SNR is improved by

choosing the alloy composition leading to a strong inter-granular exchange coupling and smaller magnetic anisotropy in the first magnetic layer of an anti-ferromagnetically coupled media. Applicants will point out that the choice of the alloy composition in the present invention is in fact opposite to the conventional teaching for improving media SNR. A larger degree of noise can be expected according to the conventional way of thinking, but Applicants have found that the employment of the alloy composition of the first magnetic layer according to the present invention is in fact effective in reducing media noise. The strong inter-granular exchange coupling and the moderate magnetic anisotropy of the first magnetic layer probably assists the magnetic reversal of the second magnetic layer and consequently contributes to the formation of clear bit transitions and media noise reduction.

The above discussion is also explained in the EXPLANATORY INFORMATION sheets attached hereto, which were provided by the Applicants. The attached information will help illustrate the effects of the composition of the invention on the properties of anti-ferromagnetically coupled media by using experimental data described in the explanatory information and in the application. EXPLANATORY INFORMATION I discusses the relationship between the thickness of first magnetic layer and the coercivity measured for the samples having the second magnetic layer with same thicknesses and compositions and the first magnetic layer with various thicknesses and compositions. The first magnetic layer compositions of examples are Co-20at%Cr-4at%P, Co-14at%Cr-5at%, Co-16at%Cr-8at%P, and Co-19at%Cr-6at%Pt. Those of comparative examples are Co-16at%Cr-6at%Pt-8at%B, Co-19at%Cr-6at%Pt-8at%B, and Co-22at%Cr-6at%Pt-8at%B. In case of conventional anti-ferromagnetically coupled media, which are shown as the EXPLANATORY INFORMATION II and the COMPARATIVE EXAMPLES, the coercivity decreases with increasing the first magnetic layer thickness. On the other hand, in case of the anti-ferromagnetically coupled media of the present invention, the coercivity increases with increasing the first magnetic layer thickness.

The first magnetic layer of the present invention plays a role of enhancing the magnetic properties of the second magnetic layer, and this role is different from that known for conventional magnetic media. Therefore, the first magnetic layer composition of the present invention is not simply the optimized results like the prior art, but produces new and unexpected effects or results. By using these unexpected effects, Applicants have been able to achieve anti-ferromagnetically coupled media with a large coercivity and a high SNR.

Because the features and advantages achieved by the present invention, as shown above, are unexpected and/or would not have been achievable given the teachings of the prior art, Applicants will contend that the present invention as claimed would not have been obvious to one of skill in the art. Rather, by relying on the teachings of the prior art, such as those of Doerner '684, the structure, operation and advantages of the present invention would not have been apparent by those skilled in the art, and thus would not have been realized.

As a result, since the present invention as claimed would not have been achieved given the prior art of record, Applicants will strongly but respectfully contend that the present invention would not and could not have been obvious to one of skill in the art given the prior art of record.

Applicants will contend that the present invention is thus as a whole distinguishable and thereby allowable. The withdrawal of the outstanding prior art rejections is in order, and is respectfully solicited.

Conclusion

In view of all the above, clear and distinct differences as discussed exist between the present invention as now claimed and the prior art reference upon which the rejections in the Office Action rely, Applicant respectfully contends that the prior art references cannot anticipate the present invention or render the present invention obvious. Rather, the present invention as a whole is distinguishable, and thereby allowable over the prior art.

Favorable reconsideration of this application is respectfully solicited. Should there be any outstanding issues requiring discussion that would further the prosecution and allowance of the above-captioned application, the Examiner is invited to contact the Applicants' undersigned representative at the address and phone number indicated below.

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EXPLANATORY INFORMATION

COMPARATIVE EXAMPLES

EXAMPLE			COMPARATIVE EXAMPLE	
First magnetic layer	Sample No.		First magnetic layer	Sample No.
	#4401A			#6003B
	#4402A		Co-18at%Cr-8at%Pt-2at%Ta	#6004B
Co-19at%Cr-6at%Pt	#4406A			#6006B
	#4407A			#6007B
	#4408A			#5604A
	#4409A		Co-12at%Cr-6at%Ta	#5605A
	#6103A			#5606A
	#6104A			#5607A
Co-20at%Cr-4at%Pt	#6106A			#6203A
	#6107A			#6204A
	#6108A		Co-20at%Cr-2at%Pt	#6206A
	#7203A			#6207A
	#7204A			#6208A
Co-14at%Cr-5at%Pt	#7207A			#6303A
	#7206A			#6304A
	#7208A		Co-16at%Cr-10at%Pt	#6306A
	#5503A			#6307A
	#5504A			#6308A
Co-16at%Cr-8at%Pt	#5507A			#6403A
	#5506A			#6404A
	#5508A		Co-19at%Cr-12at%Pt	#6406A
	#4401B			#6407A
	#4402B			#6408A
Co-19at%Cr-6at%Pt	#4407B			
	#4408B			
	#4409B			
	#6601A			
Co-19at%Cr-6at%Pt	#6602A			
	#6603A			
	#6604A			
	#7110A			

Co-19at%Cr-6at%Pt	#7106A			
	#7111A			
	#7112A			
	#5403A			
	#5404A			
Cr-15at%Ti	#5406A			
	#5407A			
	#5408A			
	#5409A			

EXPLANATORY INFORMATION I

SNR improvement mechanism

Reducing grain size and inter-granular exchange coupling of the second magnetic layer is usual way to improve medium SNR of AFC media. However, we thought that "high thermal stability" and "small magnetic anisotropy" of the first magnetic layer are important to improve medium SNR of AFC media. In this point of view, we chose the material and the composition of the first magnetic layer.

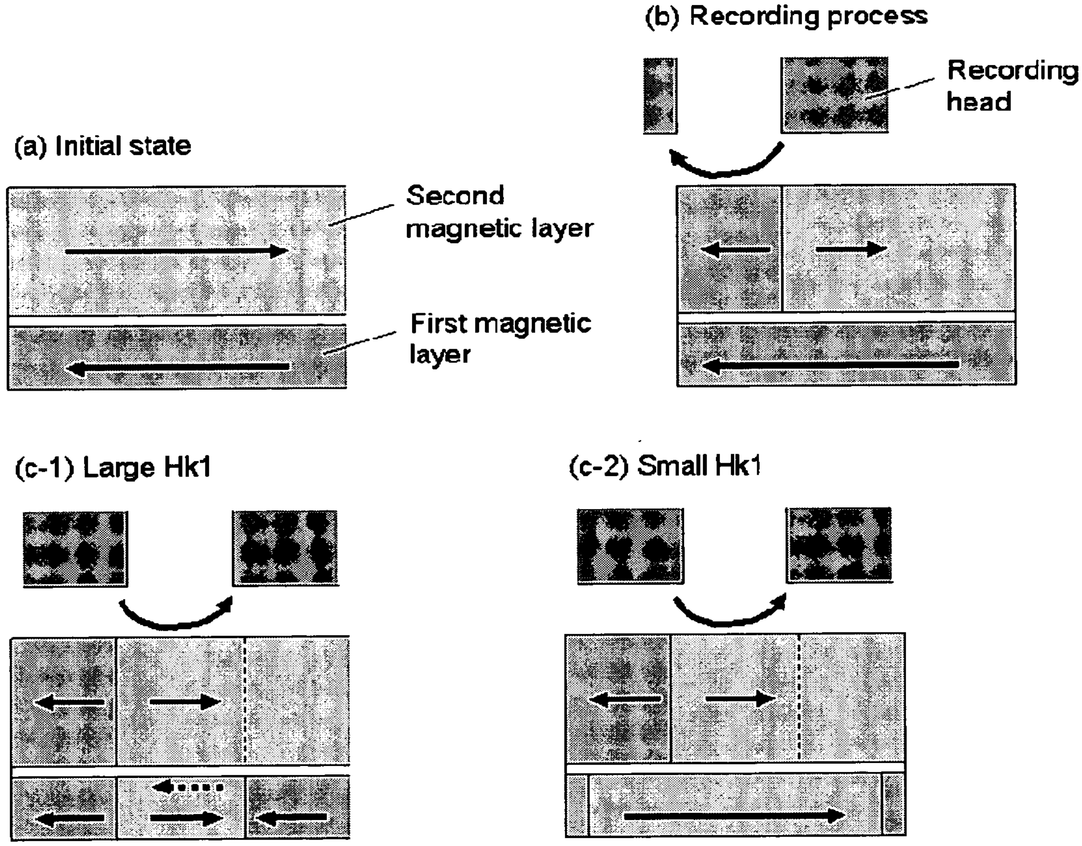
High thermal stability should be required for the first magnetic layer as well as the second magnetic layer. Because the thermal fluctuation in the first magnetic layer disturbs the magnetic recorded state in the second magnetic layer and increases the noise. Therefore, high thermal stability is necessary for the first magnetic layer. Increase of magnetic anisotropy is usual way to increase the thermal stability. In this case, Pt addition of more than 10 at% is required. However, this way is against the second important point; "small magnetic anisotropy". Increase of magnetic volume is another way to increase the thermal stability. When large magnetic volume is obtained by large grain size, large grain of the first magnetic layer leads to the large grain of the second layer and large medium noise. Therefore, we obtained the large magnetic volume by increasing the inter-granular exchange coupling.

SNR improvement by reducing magnetic anisotropy of the first magnetic layer can be explained with the recording process. The recording states are stable when the magnetic moments of the first and the second magnetic layer couple in anti-parallel direction each other in AFC media. However, on the way of recording process, head fields make the magnetic moments in parallel direction. When the anisotropy of the first magnetic layer (Hk1) is small, anti-parallel state are made just after the recording due to the reversed head field for the writing of the next bit. On the other hand, when the Hk1 is large, the parallel state is maintained after the recording. This parallel state is the cause of medium noise. I will explain it using the reference figure. The figure (a) schematically indicates the initial state, and figures (b), (c-1) and (c-2) indicate the middle of the recording process. Recording head is moving from the left to the right sides. The magnetic moment states of the first magnetic layer are different between figures (c-1) and (c-2). This difference is important. In case of large Hk1, magnetic reversal region in the first magnetic layer is almost same as that of the second magnetic layer. In this situation, demagnetization field arise in the opposite direction to the head field. The demagnetization field is shown with dashed line in the figure. The demagnetization field weakens the head field and disturbs the formation of sharp bit transition. It is a problem in improving the medium SNR. Therefore, small Hk1 is better for getting better SNR.

EXPLANATORY INFORMATION I

To obtain both of "high thermal stability" and "small magnetic anisotropy", the strong inter-granular exchange coupling and the reduced magnetic anisotropy are required for the first magnetic layer. The "reduced anisotropy" means small but not too small anisotropy, because too small anisotropy loses thermal stability. To realize both of them, CoCrPt alloy containing 3-9 at% Pt is a suitable material.

REFERENCE FIGURE



EXPLANATORY INFORMATION II

Comparison between the prior art (Doerner US6537684) and the invention

Our patent insists a special effect on the media SNR improvement which obtained only when the CoCrPt-alloy containing 3-9 at% Pt is employed to the first magnetic layer. On the other hand, Doerner (US6537684) insists importance of no B alloy for the first magnetic layer and the allowable Pt content in CoPtCr-alloy available for the first magnetic layer is 0-15 at%. The range is wide enough to cover almost all the composition of the conventional CoPtCr-alloy magnetic layer used for the magnetic recording media.

To make the difference in the SNR between the Doerner and our invention clearer, we plotted and compared many SNR data described in our specification. We chose the samples whose first magnetic layer was formed on the CrTi-alloy underlayer and contained no B. The results are shown in the reference figure. There is clear difference in SNR between the examples and the comparative examples, although both of them include samples with various thicknesses and/or various materials of the magnetic layers, which affect the SNR somewhat. The average SNR of the examples and the comparative examples are 24.4 and 23.2 dB, respectively. The special effect of our invention pushes up the SNR by 1.2 dB. Such an improvement of SNR is large enough to increase areal density of hard disk drive.

EXPLANATORY INFORMATION II

REFERENCE FIGURE